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ABSTRACT

This study examined four measures of creativity as predictors of mathematics and science performance in a program for talented high school students (N=29). Correlational analyses indicated that the How Do You Think Test (HDYT) and ratings on the Teachers' Evaluation of Students' Creativity (TESC) were predictive of the students' performance in the Student Science Training Program (SSTP) at the University of Hawaii. Preliminary Scholastic Aptitude Test in Mathematics (PSAT-M) scores were also positively correlated with participants' performance. Additionally, scores from the HDYT test were significantly different in high- and low-performance groups even after controlling for differences in PSAT-M scores. These findings suggest that the HDYT test be used in the selection of participants for this program. (Author/MNS)

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Creativity, Extracurricular Activity, and Divergent Thinking as Predictors of Mathematics and Science Performance by Talented Adolescents

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Abstract

The present investigation was an empirical examination of four measures of creativity as predictors of mathematics and science performance in a program for talented high school students (N = 29). Correlational analyses indicated that the How Do You Think Test (HDYT) and ratings on the Teachers' Evaluation of Students' Creativity (TESC) were predictive of the students' performance in SSTP. Preliminary Scholastic Aptitude Test in Mathematics (PSAT-M) scores were also correlated with participants' performance. Additionally, scores from the HDYT test were significantly different in high- and low-performance groups even after controlling for differences in PSAT-M scores. These findings suggest that the HDYT test be used in the selection of participants for this program.

Creativity, Extracurricular Activity, and Divergent Thinking as Predictors of Mathematics and Science Performance by Talented Adolescents

Each Summer, a group of high school students participates in the Student Science Training Program (SSTP) at the University of Hawaii at Hilo. A battery of tests was administered to the 1986 SSTP partcipants in an attempt to improve the prediction of performance in SSTP. This investigation was conducted to facilitate the and selection identification of participants in SSTP. The emphasis is on measures of creativity and relevant extracurricular activity.

The present investigation is the report on the "predictive validity" of these measures. A description and rationale for each instrument is given below, followed by a Results section and a Conclusion and Recommendations section.

The How Do You Think Test

The How Do You Think (HDYT) test was developed by Davis (1975). It is a self-report, containing 100 items concerning feelings, attitudes, and beliefs. The HDYT was chosen because it is a measure of creative attitudes, and attitudinal assessments are believed to greatly improve the accuracy of predictions of academic and extracurricular performance (Renzulli, 1978; Willingham, 1986).

Divergent Thinking Tests

The Instances, Similarities, and Uses Divergent Thinking (DT) tests from the Wallach and Kogan (1965) battery were adapted and administered. Each test had four items--three standard items and one unstructured item. The unstructured item was included in order to assess "problem-discovery" ideational skill (Wakefield, 1985). The unstructured item allowed the student to create their own problem before providing solutions.

Creative Activities Check List

This is a fifty-five item check list designed to assess extracurricular creative activities. This particular measure is similar to check lists used by Holland (1961), Hocevar (1983), and Wallach and Wing (1969); but this check list contained relatively more items for math and science activity than earlier versions. It also contained literature, art, and craft scales for comparisons among domains.

Teachers' Evaluation of Students' Creativity (TESC)

The TESC is a 25 item observational measure which was developed by Runco (1984). He demonstrated that it is reliable and valid as a measure of creative potential in school children. In the present investigation, the SSTP Director and two Counselors rated each participant using the TESC. An average

score was calculated (after reversing the contraindicative items) for each rater, and a total score was calculated as the sum of the three raters' scores.

Other Predictors

Other predictors (already used by SSTP) were: GPA and Preliminary Scholastic Aptitude Test Mathematics (PSAT-M) and Verbal (PSAT-V) scores. These were all taken from the applicants' school records.

Criteria

The criteria of performance included three examination scores, laboratory reports, and "field trip" reports. The examinations covered lecture material, with three hour lectures given four times each week. The first examination was administered at the end of the second week. This examination focused on calculus and introductory physics. The second examination was administered at the end of the fourth week, and focused on the integration of calculus and physics. The final examination covered all material from the seven weeks of lecture and was administered on the last day of instruction. Each examination was two hours in duration, contained between 10 and 15 calculus and physics problems, and had a maximum score of

100. Descriptive statistics for all criteria are given in Table 1.

Each student was also required to conduct two, 3-hour experiments each week. The topics included Measurements and Graphical Representation, Simple Pendulum, Analysis of Experimental Errors, Dimensional Analysis, and Individual Projects. A report discussing the data, findings, and conclusions of the experiment was required for each experiment. Reports were also graded on a 10 point scale.

Each Friday, students were taken on a "field trip" to scientific laboratories and installations on the island. For each field trip, students were required to write a short report about the function of the facility, equipment observed, type of work conducted, and "what was learned" from the visit. These reports were graded on a 10 point scale.

Results

Descriptive Statistics/Age and Gender Effects

Means and standard deviations for all measures are presented in Table 1. A multivariate analysis of variance (MANOVA) was conducted using each of the Activity Check List scores as dependent variables, gender as a between subjects factor, and age (in months) as a covariate. Results indicated that age was unrelated to the Activity scores. Gender was not significantly related to the Activity Check List scores in the multivariate

Table 1

Means and Standard Deviations (N = 29)

	Mean	SD
DT	11.5	3.07
Unstructured DT	19.1	7.30
HDYT	311.8	34.02
TESC Total	13.1	1.35
Rater 1	4.5	0.54
Rater 2	4.5	0.68
Rater 3	4.2	0.47
Activity		
Math	2.1	0.45
Science	1.8	0.36
Crafts	2.1	0.43
Literature	2.1	0.54
Art	1.9	0.58
Examinations		
# 1	64.6	23.35
# 2	59.5	25.95
Final	35.4	19.21
Reports		
Lab[a]	29.7	8.98
Field[b]	41.6	4.47
PSAT-V	53.7	11.48
PSAT-M	65.1	8.40

[a]sum of 4 reports
[b]sum of 5 reports

test (R_c = .55), and only Literature had a significant univariate gender effect (F (1,26) = 8.12, p < .01). The girls' Literature scores (M = 2.46, sd = .58) were higher than the boys'(M = 1.91, sd = .43). A similar MANOVA indicated that age and gender were unrelated to HDYT, TESC, and DT scores.

A final MANOVA was conducted to test age and gender effects on the PSAT scores, and the scores from the five criteria. Results indicated that age was unrelated to the criteria scores, with a canonical coefficient of .34. The canonical coefficient of gender was high (R_c = .61, ns), but only the univariate test of field reports was significant (F (1,26) = 9.28, p < .01). The mean for the boys' field reports was 39.8 (with a sd of 4.12) and the mean for the girls' reports was 44.70 (with a sd of 3.34).

Reliability

The interitem consistency of the Activity Check List scores was as follows: Math (nine items, alpha = .47), Science (16 items, alpha = .74), Art (eight items, alpha = .75), Crafts (12 items, alpha = .61), and Literature (10 items, alpha = .76). Interrater agreement was used as an index of reliability for the TESC, and this was evaluated by checking the correlations among the scores from the three raters. The three product-moment correlations were .46, .35, and .57. When the internal

consistency of the TESC was taken into account (using the median interitem alpha of .93, and an r-to-z transformation), the adjusted interrater coefficient was .48.

Predictive Validity

Predictive validity was first examined with canonical correlational procedures. These procedures calculate an optimal composite of a set of predictors (the Activity Scales in this first analysis) and an optimal composite of a set of criteria (the scores from the three examinations and two reports). These two composites, or "variates," were highly related, with two orthogonal functions (R_c = .61 and .56). Regression analyses using each Activity Scale score resulted in the following validity coefficients: Mathematics (R = .37), Science (R = .32), Literature (R = .41), Art (R = .43), and Crafts (R = .60). While only the correlation with Crafts was statistically significant (F (5,23), = 2.65, $p < .05$), each coefficient is relatively high for a predictive validity coefficient (Nunnally, 1978).

A canonical analysis using the HDYT, DT, and TESC scores as predictors resulted in a highly significant validity coefficient (R_c = .77, F (20,67) = 1.90, $p < .05$). Regression analyses resulted in the following coefficients: standard DT (R = .45), unstructured DT (R = .27), HDYT (R = .68, $p < .01$), and TESC

total (R = .65, p < .05).

Another canonical analysis was conducted to examine the predictive validity of the two PSAT scores and GPA. Results indicated that these three predictors were significantly related to the criteria of SSTP performance (R_c = .78, p < .01). Regression analyses indicated that each of the three predictors was significantly correlated with the criterion variate (R = .59 for PSAT-V, .72 for PSAT-M, and .49 for GPA).

Group Comparisons

Another way to examine the relationship of the predictors and SSTP performance is with group comparisons. To do this, a principal components analysis was conducted with the criteria scores (the three examinations and the two reports). Two orthogonal factors were extracted (with eigenvalues of 2.48 and 1.33) accounting for 49.5% and 26.5% of the variance (the total variance accounted for was 76.1%). The factor matrix (given in Table 2, see next page) indicated that there was one Examination factor and one Report factor.

Factor scores were calculated using this solution, and these were in turn used to form four groups (see Table 3). A MANOVA was conducted to compare these groups in terms of the PSAT-V, PSAT-M, and GPA data. Results indicated that the two Factor I groups were significantly different in the multivariate test

Table 2
Factor Solution

	Factor I	Factor II
Examination #1	.878	-.064
Examination #2	.939	-.192
Final	.893	.064
Laboratory	.098	.794
Field Trip	.125	.807

multivariate test (R_c = .63, F (3,23) = 4.96, p < .01) and the univariate test for PSAT-M (F (1,25) = 11.97, p < .01). The Factor II groups were not significantly different.

A similar MANOVA was conducted to compare the groups in terms of the five Activity scores. Results indicated that the groups were not significantly different in the multivariate test or the univariate tests.

A third MANOVA was conducted to compare the four groups in terms of HDYT, TESC, DT, and unstructured-DT scores. Results indicated that the Factor II groups were significantly different in the univariate test for the HDYT scores (F (1,25) = 8.24, p < .01). Additionally, the Factor I groups were different in the multivariate test (R_c = .59, F (4,22) = 2.88, p .05) and the univariate test of HDYT scores (F (1,25) = 5.95, p < .05).

Table 3
Means (and Standard Deviations) for the Four Groups

	Group I	Group II	Group III	Group IV
PSAT-V	48.4 (8.3)	58.4 (8.3)	51.3(13.6)	56.5(14.1)
PSAT-M	61.1 (6.2)	59.9 (8.6)	70.0 (5.4)	69.9 (8.2)
GPA	3.8 (0.3)	3.9 (0.2)	3.7 (0.4)	3.8 (0.2)
Exam #1	52.8(22.8)	48.6(23.7)	76.3(18.6)	81.6(8.1)
Exam #2	48.5(22.4)	38.1(23.1)	77.7(15.6)	78.5(13.7)
Final	22.8(12.7)	21.3(10.9)	39.7(12.5)	57.1(12.1)
Lab	23.5 (6.6)	37.7 (3.9)	21.3 (6.5)	35.0 (6.0)
Field	39.3 (3.9)	42.7 (3.1)	38.1 (3.1)	45.4 (3.2)
DT	11.1 (3.5)	13.5 (2.8)	10.2 (2.5)	11.2 (3.0)
Unstrct. DT	18.6 (8.4)	21.9 (5.3)	21.8 (9.9)	14.9 (3.7)
HDYT	303.4(39.4)	345.6(20.9)	288.7(28.3)	308.0(20.7)
TESC	13.2 (1.7)	12.3 (0.9)	13.2 (1.3)	13.9 (1.0)

Note: The participants who were below the median on both factor scores are in Group I (n = 8); the participants who were below the median on the Examination factor but above the median on the Report factor are in Group II (n = 7); the participants who were above the median on the Examination factor but below the median on the Report factor are in Group III; and the participants who were above the median on both factors are in Group IV (n = 8).

With the group differences especially obvious in PSAT-M and HDYT scores, a final MANOVA was conducted to compare the HDYT and PSAT-M scores. This analysis involved hierarchical regression tests, so unique variance of the HDYT scores (i.e., variance not shared with PSAT scores) could be tested.

Results indicated that the PSAT-M and HDYT scores were significantly different in the two Examination Factor groups (R_c = 70, $p < .001$) and the two Report Factor groups (R_c = .52, $p < .05$). More importantly, the hierarchical regression analyses indicated that the HDYT scores were significantly different in the two Examination groups (F (1,24) = 7.92, $p <$ .01) after the PSAT-M scores were controlled. Similarly, the HDYT scores were significantly different in the two Report groups (F (1,24) = 8.91, $p < .01$) after the PSAT-M scores were controlled.

Conclusions and Recommendations

The correlational results indicate that the scores of the measures used in the selection of SSTP participants are highly correlated with the performance of the participants in the program. In particular, the HDYT and TESC scores were predictive of performance in the SSTP, as were the PSAT scores. Note that these coefficients would probably be higher in a less restricted sample.

The results from the group comparisons are particularly suggestive. The use of the HDYT test was strongly supported, for scores on the HDYT test were significantly different (for both factors) before and after controlling PSAT-M scores. One recommendation is, then, to include the HDYT in the battery of selection materials. Perhaps a "multiple cutoff" technique (Anastasi, 1984) could be used in which minima of both PSAT and HDYT are employed for selection of participants.

With the small sample size of the present investigation (N = 29), these findings should be viewed as tentative. A replication and extension should be conducted. Another limitation of this investigation is the lack of criteria from beyond the training program. Future research could use college selection, college GPA, college creative activity, and perhaps post-graduate indices as criteria.

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